

WHAT IS CLAIMED IS:

1. A method for forming a thin metal film layer on a solid substrate surface comprising:

(a) selecting a chemical reaction which requires at least two different reagents to produce said metal, wherein the reaction can be divided into a plurality of separate self-limiting reactions; and

(b) sequentially conducting the plurality of self-limiting separate reactions to produce the thin metal film layer on the solid substrate surface.

2. The method of Claim 1, wherein the reaction comprises a binary reaction.

3. The method of Claim 1, wherein the reagent introduced for reaction with the solid material is in a gaseous state.

4. The method of Claim 1, wherein at least one of the reagents in the chemical reaction is a metal halide.

5. The method of Claim 4, wherein at least one of the reagents in the chemical reaction is a metal halide reducing agent.

6. The method of Claim 1, wherein the solid substrate surface comprises a functional group which can be activated to undergo the chemical reaction.

7. A method for producing a solid material comprising a thin film of metal on a solid substrate surface, said method comprising:

(a) contacting said solid substrate surface with a metal halide under conditions sufficient to produce a metal halide surface;

(b) contacting said metal halide surface with a silylating agent under conditions sufficient to produce a metal-silicon surface; and

(c) contacting said metal-silicon surface with metal halide under conditions sufficient to produce said thin metal film surface.

8. The method of Claim 7, wherein said solid substrate surface comprises a group selected from oxides, nitrides, metals, semiconductors, polymers with a functional group, and mixtures thereof.

9. The method of Claim 7 further comprising contacting said solid substrate surface with the silylating agent prior to said step (a).

10. The method of Claim 9, wherein said solid substrate surface comprises a hydroxide.

11. The method of Claim 7, wherein said metal halide is a transition metal halide, or halide of a semiconductor.

12. The method of Claim 7, wherein said metal halide is selected from the group consisting of tungsten fluoride, rhenium fluoride, molybdenum fluoride, antimony fluoride, selenium fluoride, thallium fluoride, chromium fluoride, platinum fluoride, ruthenium fluoride, iridium fluoride, and germanium fluoride.

13. The method of Claim 12, wherein said metal halide is tungsten fluoride.

14. The method of Claim 7, wherein the silylating agent comprises silane, disilane, trisilane and mixtures thereof.

15. The method of Claim 7, wherein said thin metal film surface comprises metal-metal halide surface.

16. The method of Claim 15 further comprising repeating said steps (b) and (c) to obtain a desired thickness of said metal film.

17. A method for forming a thin metal film on a solid substrate surface comprising:

(a) contacting said solid substrate surface with a metal fluoride under conditions sufficient to produce a metal fluoride surface;

(b) contacting said metal fluoride surface with a silylating agent under conditions sufficient to produce a metal-silicon surface; and

(c) contacting said metal-silicon surface with metal fluoride under conditions sufficient to form a thin metal film on the solid substrate.

18. The method of Claim 17, wherein said metal is selected from the group consisting of tungsten, rhenium, molybdenum, antimony, selenium, thallium, chromium, platinum, ruthenium, iridium, and germanium.

19. The method of Claim 17, wherein said metal fluoride has vapor pressure of at least about 0.1 torr at 100 °C.

20. The method of Claim 17, wherein said thin metal film surface comprises metal-metal halide surface.

21. The method of Claim 20 further comprising repeating said steps (b) and (c) to obtain a desired thickness of said metal film.

23. The method of Claim 17 further comprising contacting said solid substrate surface with the silylating agent prior to said step (a).

7

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25. A solid material comprising a solid substrate having a thin metal film layer, wherein the ratio of roughness of the solid substrate surface to the roughness of the solid material surface is from about 0.8 to about 1.2.

26. The solid material of Claim 25, wherein the roughness of a flat portion of said solid material is about 50% or less of roughness of a substantially same solid material produced by a chemical vapor deposition process.

27. The solid material of Claim 25, wherein the thickness of said metal film layer is about 100 Å or less.

28. The solid material of Claim 25, wherein said metal is tungsten.

29. The solid material of Claim 28, wherein the thickness of said metal film layer is substantially $(2.5 \text{ Å} \times n)$, wherein n is an integer.

30. The solid material of Claim 25, wherein said solid substrate comprises a conducting, insulating or a semiconductor material.

31. A solid material comprising a solid substrate having a thin metal film layer, wherein the roughness of a flat portion of said solid material is about 50% or less of roughness of a substantially same solid material produced by a chemical vapor deposition process.

32. The solid material of Claim 31, wherein the ratio of roughness of the solid substrate surface to the roughness of the solid material surface is from about 0.8 to about 1.2.

33. The solid material of Claim 31, wherein said metal is tungsten.

34. The solid material of Claim 33, wherein said solid substrate comprises a conducting, insulating or a semiconductor material.